OBSERVATIONS UPON THE OSTEOLOGY OF THE NORTH AMERICAN ANSERES.

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This well-circumscribed order or group agrees with Huxley's *Chenomorphæ*, and contains the Mergansers, Ducks, Geese, and Swans.

For some time past I have been accumulating the material for a memoir upon the osteology of the entire group of lamellirostral birds of this country. I still lack, however, quite a number of important forms, which may take more or less time to secure. So that the present memoir must not be considered more than an introduction to the subject, though here it has the claim of introducing a number of drawings of those forms, which can be compared with advantage with other species which I did not happen to have in my possession at the time this was written.

Much of the anatomy of the anserine birds is known to us already, but that further elucidation in this direction is very desirable I hardly think any one will question. Garrod gave the subject no little attention, though he confined himself principally to the condition of the carotids, the presence or absence of certain muscles, and the form of the osseous portions of the air-passages in a number of the rarer types of Ducks. As I have just said, Huxley, in his famous essay upon the Classification of Birds, created a separate group—the *Chenomorphæ*—to contain, with a few related forms, the *Anatidæ*, a division based upon anatomical characters so far as they were known at the time.

Coues, in 1884, in the second edition of his Key, availing himself of all that was known up to that period which could be successfully utilized in classification, awards the anserine birds the order *Lamellirostres*, dividing it into the suborder *Odontoglossæ* for the single family of the Flamingoes, and the suborder *Anseres* to hold the Swans, Geese, River and Sea Ducks, and the Mergansers, these latter each having a separate subfamily created for it, to wit, The *Cygninæ*, the *Anserinæ*, the *Anatinæ*, the *Fuligulinæ*, and the *Merginæ*, respectively. Collectively these subfamilies constitute the family *Anatidæ* of this author. Some few unimportant changes were made in the American Ornithologists' Union Check-List, but this classification remains substantially the same.

Even by their external characters, the Swans, Geese, and Ducks, and the more modified Mergansers form a very sharply-defined group of birds, and morphology has made quite clear to us the probable relation the Flamingoes bear to them. So that it is not very likely that further investigations will materially disturb the classification now adopted and presented in the Check-List of the American Ornithologists'

Union. In fact, every advance anatomy has made in that direction seems to have been attended by the one result, and that to assure us of the soundness of the arrangement in question.

Instead of this being a signal, however, for the anatomist to cast his eyes from this line of work and slacken the activity of his scalpel in what he may think profitless employment, it all the more devolves upon him to push his researches to a point nothing short of a perfect knowledge of the structure of these forms. That we have not arrived at any such state of perfection I could easily point out. As I have elsewhere shown, even so profound an anatomist as Huxley, from lack of material and established data, may occasionally fail to properly define an important characteristic, as he did in describing the sternum of these very *Chenomorphæ* (P. Z. S., 1867). Again, it is but recently that Dr. Baur, of Yale College, claims to have discovered an additional joint in the last digit or the middle finger of the embryo of the common Duck, a structure which is said to be visible at about the time of hatching.

I have never had reason to change my opinion as to the value, the incalculable value, of a complete knowledge of the morphology of those living forms best known to us. With such a knowledge of the structure of the anserine fowl we are far better prepared to push our investigations, with infinitely greater chances of assured results into the structure of allied groups than if we were not quite certain of each and every detail in the organization of these known forms.

The *Anseres* are well represented in the United States, and abundant opportunity is afforded to study their structure.

Further work is much needed in this line upon the air passages of the entire group, the generative organs, and other special parts.

The *Merginæ* constitute the first subfamily under the *Anatidæ*, and it has been awarded two genera in our fauna, viz, the genus *Merganser* of Brisson, containing the Mergansers, and the genus *Lophodytes* of Reichenbach, created to contain the Hooded Merganser (*L. cucullatus*).

The Mergansers present us with some very interesting points in their osteology, and the majority of these can be studied in the skeleton of *Mergus serrator*, a very good specimen of which bird I have now at hand. I am indebted to the Smithsonian Institution for the loan of it (No. 16626 of the Smithsonian Institution collection), and will now describe its skeleton.

OBSERVATIONS UPON THE OSTEOLOGY OF MERGUS SERRATOR.

Of the skull.—We find in this bird that the lamellæ of the bill develop tooth-like serrations for the entire length of both mandibles. These pseudo teeth, however, make no impression whatever upon the osseous base of the bill, and in a well-prepared skeleton we would never suspect their existence. Upon lateral view of this skull (Fig. 1) we see that the superior mandible curves slightly upwards as we proceed toward its apex; the lower margin is sharp, and above it is convex, except in the cranio-facial region and somewhat beyond, where it is depressed.

A *nasal* is a large, broad bone; its anterior margin is rounded as in other holorhinal birds. The nostril is elliptical and placed horizontally, and the sutural traces of the bones that surround it entirely obliterated. A *lacrymal* bone is triangular in form, its apex below terminating in a spindle-form process, which is curved somewhat outward. Along its superior border it anchyloses with the frontal and nasal, the sutural trace being quite distinct in the adult skull. Not so, however, in most of the Ducks and Geese.

All anserine birds seem to possess a slender jugal bar; in the case of the Red-breasted Merganser, its distal end turns abruptly upward to make its articulation with the quadrate.

This latter bone has its orbital process widely bifid; its mastoidal head is single and roundly convex.

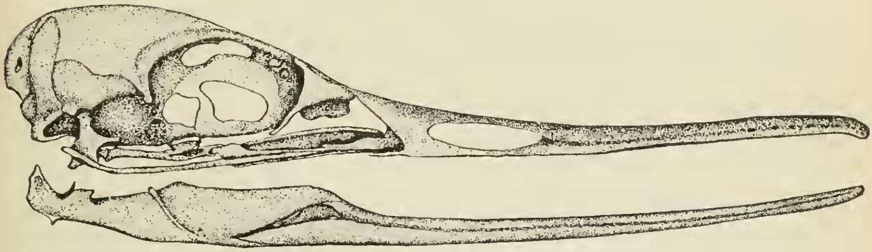

FIG. 1. Skull of *Mergus serrator*; right lateral view; life size. By the author, from specimen 16626, Smithsonian collection.

The facets at its mandibular foot are two in number, placed obliquely. They differ considerably in form and position from the same parts as seen in a specimen of a Brant before me.

The sphenotic process is prominent and gradually curves downward along its extent. In most Ducks it points downward and forward.

We find the hinder moiety of the superior orbital periphery rounded off for the lodgment of the nasal gland. The extent to which this is carried varies in the different species of anserine fowl.

About the center of the interorbital septum there occurs a large fenestra, and the foramina for the exit of the first and second pair of nerves are much larger than necessary for this purpose alone.

The pars plana is a very thin, curved sheet of bone, which supports in front a crumpled mass of equally attenuated osseous tissue. This latter projects into the upper space of the rhinal chamber, and no doubt plays the part of a turbinated bone. Neither of these outgrowths come in contact with the inner aspect of the lachrymal bone of the same side.

The lower margin of the rostrum is straight, rising gently upward as it is projected forward, being sharp below along its anterior moiety.

Anteriorly the ethmoid has an elongo cordate outline, the base of the figure abutting against the under side of the cranio-facial region.

Viewing this skull from beneath we notice a long, narrow cleft in front of the maxillo palatines and bounded on either side by a dentary process of the premaxillary. This cleft is deepest behind and gradually becomes shallower as it proceeds to the front, where it disappears just behind the rounded mandibular apex.

The *maxillo-palatines* are thin, horizontal plates that are in contact for their anterior halves in the median line, but diverge as rounded, distinct processes for their posterior moieties. These processes project into the wide interpalatine cleft, but do not come in contact either with the palatine bones nor with the *vomer*. This latter is a long, thin plate of bone that is grasped by the small ascending processes of the palatines behind to anchylos with them, while above it is finished off with a rib-like margin which is produced beyond the plate in front as a long spiculiform process, with its apex resting upon the middle of the maxillo-palatine median suture.

Each *palatine* body is a narrow lamina of bone, the anterior end of it dilating somewhat before being inserted between and fused with the other elements in front.

These palatines only meet each other, and that only in a point, behind their common seizure of the hinder end of the vomer. Nor do they come in contact with the under border of the rostrum, as they are prevented from doing that by the sessile, though large and elliptical, basipterygoid facets found upon the latter.

Their heads are separated behind by quite an interval, and each one makes a peculiar combination joint with the corresponding head of the pterygoid, which develops the reverse articulation for it.

Immediately posterior to this a *pterygoid* supports also a sessile elliptical facet of precisely the same character as the one referred to above as occurring on the rostrum, the two coming in contact to form a perfect sliding joint, with smooth and plane surfaces opposed to each other.

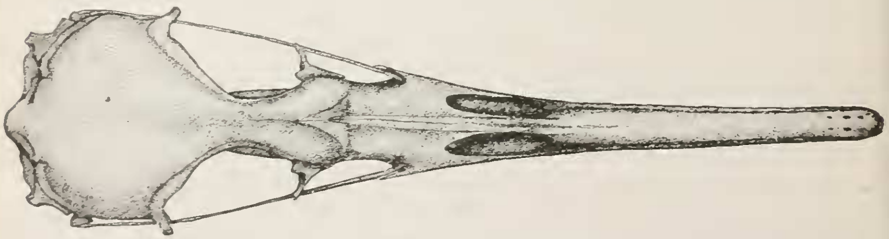

FIG. 2. Skull of *Mergus serrator*: viewed from above, mandible removed; life size. By the author, from specimen 16626, Smithsonian collection.

Posterior to this articulation a pterygoid is somewhat compressed from above downward, and curves gracefully outward to cover with its cup like hinder end the spheroidal facet offered to it on the part of the corresponding quadrate.

The basi-temporal region is broad and smooth, and a spine-like process at its apex fails to shut out from view the double orifice leading to the Eustachian tubes.

We find the major portion of the crotaphyte fossa upon the lateral aspect of the skull. Still it may be seen also from a posterior view, where the two depressions approach each other, but are separated by a large dome-like, supra-occipital prominence.

This latter is usually pierced by an irregular foramen on either side, which is quite characteristic but not always present in the Ducks and Geese. In a specimen of *Branta canadensis hutchinsii* before me a large one occurs only on the left side of the prominence.

Mergus has a large foramen magnum which faces almost directly backward. The occipital condyle at its lower margin is of a reniform outline with the notch above.

In the *mandible* the symphysis is short, and this bone, when seen from a superior aspect, is of an acute V-shape form.

The anterior two thirds of either ramus is narrow, tapering somewhat to the front, with both upper and lower borders rounded. On the outer surface a deep, median, and longitudinal groove of hair-like proportion is drawn along its entire length.

The hinder third is much wider, nearly double the width, and, instead of being thick like the fore part of the bone, is a vertical lamelliform plate. Its border is sharp above, while below it is rounded, being in the same line with the inferior border of the anterior two-thirds.

The ramal fenestra is nearly or quite closed in by the surrounding elements; a long, oblique slit marks its site. A curved projection is developed on the outer aspect of this part of the bone; that above apparently takes the place of part of the coronoid process.

Each mandibular facet presents two oblique grooves upon an area contracted to the minimum extent that would accommodate the mandibular foot of the quadrate that articulates with it.

Behind, either angle is produced backwards as a recurved and vertical lamina of bone, to the inner side of which we find the circular entrance to a deep conical pocket.

Mergus serrator has an enormous bilobed tracheal tympanum at the pulmonic bifurcation of its windpipe. These interesting structures vary much in form and size in the different species of birds that possess them, and would well repay a general comparison.

Of the vertebral column and ribs.—This Merganser has sixty-one vertebræ in its spinal column; the first pair of free ribs occurring on the sixteenth; then follow five others that have ribs connecting with the sternum by costal ribs; seventeen anchylos to form a sacrum for the pelvic bones; and, finally, we find seven free caudal vertebræ besides a pygostyle. All these segments are freely movable upon one another, except those in the sacrum. In *Mergus* the odontoid process of the second vertebra does not perforate the cup of the atlas from behind, but both these segments, in common with many Ducks, present the interesting condition of having the lateral vertebral canals at the outer sides of their centra, for the protection of the vessels that pass through them. This canal is a very prominent feature through all of these cervical vertebræ through the twelfth; in the first five or six it has a fenestra in its lateral wall on either side. With the exception of the last few vertebræ in which it occurs, it extends nearly the full length of the centra, while its inferior wall includes the greater part of the parial parapophyses, and these latter being rather widely separated, we have as a result a broad area at the under side of all of these vertebræ where this construction obtains.

The hyapophysial canal is found in the sixth to the twelfth, inclusive, but in none of these does it close in entirely, though the processes approach each other very near in the last-mentioned vertebra.

Axis vertebra has a prominent hyapophysis, but it is missing in the third vertebra, and this process does not make its appearance again until we find it as a conspicuous median plate in the thirteenth. In the fourteenth it is smaller, and although still in the vertical plane, evidently moved slightly to the left of the median line. This last condition is more pronounced in the fifteenth, while in the sixteenth, where it still possesses considerable size, it is carried so far to the left as to be nearly in the same plane with the side of the vertebra, though it still remains vertical. Sixteenth vertebra also has lateral hyapophysial cornua, which makes this peculiar shifting of its mid-process all the more striking. I am unable to say at present whether this is a constant condition of affairs or not. The dorsal series also have hyapophysial processes; these are at first short, with spreading cornua, to gradually become longer and lose their terminal bifurcation, and again grow shorter, to finally disappear on the first sacral, or dorso-lumbar.

Axis has a thick and heavy neural spine. In the following six or seven segments this gradually becomes longer, lower, and thinner, to be absent entirely in the tenth cervical vertebra. In the fourteenth it re-appears, and from it, backward, it gradually assumes the broad, oblong plate which is perfected in the dorsal series. The vertebræ of this latter region are restricted in their movements upon one another by the many interlacing tendinal and metapophysial spiculæ among them.

In the cervical region the neural canal is cylindrical in form, and owing to the fact that neither the pre- or postzygapophysial facets are upon spreading limbs, in its anterior division this tube is wonderfully well protected, its walls being nearly continuous from one vertebra to the next. This condition does not obtain in the latter half of the cervical region, however, where the prolongation of the aforesaid apophyses lend to the dorsal aspects of the vertebræ, when viewed from above, that familiar capital-letter-of-X appearance, with the extremities of the lines alternately articulating above and below.

This disappears again in the dorsal series, where they are closely interlocked with each other, and the neural tube once more becomes continuous. For the rest we find that the "heterocœlous" plan of articulation prevails among these vertebræ thus far described; that the centra are much compressed laterally in the dorsal region, where also the transverse processes are unusually wide and some of their spiculiform interlacements more than commonly broad. With the exception of the atlas they are all pneumatic.

The pair of free ribs that are attached to the sixteenth vertebra are long and pointed, with free extremities. They do not, however, bear epipleural appendages.

Nothing peculiar marks the ribs of the dorsal series nor the hæmapophyses that connect them with the sternum. The epipleural appendages are large and all are closely, though freely, articulated with the posterior borders of their ribs.

The first pair of sacral ribs are like the dorsal ones, except they have no epipleural appendages. The last two sacral pair, however, anchylos with the pelvis, and their hæmapophyses do not reach the sternum.

Of the sternum (Figs. 3 and 4).—*Mergus* has an interesting form of this bone, and it differs in a number of points from the sterna of its supposed nearest allies among the Ducks. The body is of an oblong outline and moderately well concaved above. Right over the anterior border in the median line there is a single semi-globular pit, but there appears to be no pneumatic foramina of any size at its bottom.

The costal processes are large, prominent, and quadrate plates. They extend behind the first hæmapophysial facet. These latter articulations are six in number, and the lateral borders behind them are sharp, curving at first outward, before they extend backward, to the xiphoidal margin.

Upon the convex, pectoral aspect of the bone we are to notice the principal muscular lines. These extend directly backward, one on either side, from the lip of bone that overarches the outer end of the coracoidal groove, to pass along the inner side of the vacuities behind, where they become very faintly marked.

A transverse straight line limits the xiphoidal extremity, and engrafted upon this in its middle we find a distinct convex prolongation of no great size, its base being rather less than one-third of the border upon which it occurs.

Just over this latter, in the apertures of the postero-external angles of the bones, we find on either side a large, oval fenestra.

A sternum of this shape, differing as it does in this particular from the notched style of the bone among most of the Geese and Ducks (for it is the same as we find it in *Glaucionetta*), forms an exception to the character laid down by Huxley for his *Chenomorphæ*, which includes the subfamily to which *Mergus* belongs. (Fig. 3.)

The extensive coracoidal beds of the anterior border are separated by a pit in the median line, and not a vestige of such a thing as the manubrium is to be seen.

From the pit just mentioned to the far-projecting carinal angle a straight osseous welt is raised, above which the anterior margin is convex and sharp.

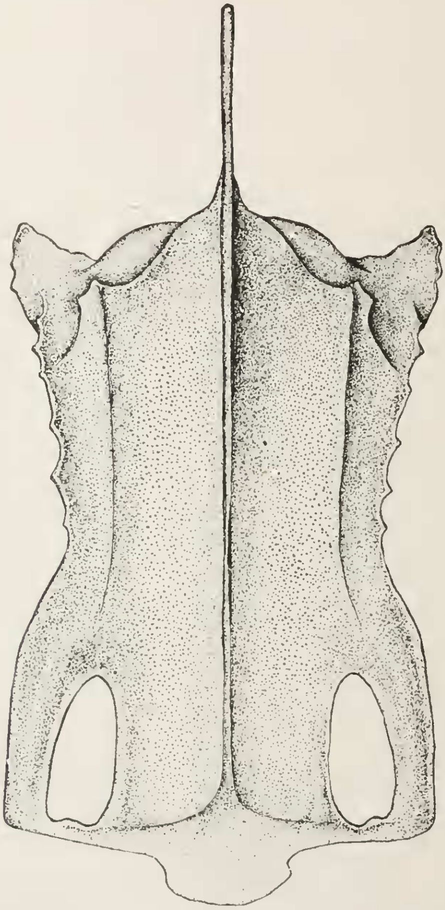

FIG. 3. Sternum of *Mergus serrator;* pectoral aspect; life size. By the author, from specimen 16626, Smithsonian collection.

The keel itself is low and extends clear back to the hinder margin of the bone proper; its inferior border is thickened and gently convex throughout its extent.

As a very good example of the appearance of the sternum among the Ducks I present a drawing of the pectoral view of the bone chosen from the American Eider (*S. dresseri*, Fig. 13). In this form the profoundly two-notched hinder portion is well shown, and here, too, we observe that the anterior part of the keel does not project as in *Mergus*, though it is not an uncommon thing to find it so even among true Ducks.

Of the shoulder girdle (Fig. 5).—Most Ducks, and I believe all the Mergansers, have a non-pneumatic pectoral arch. It is the case in our present subject, and in a number of the former at my hand.

The *furcula* typifies the broad U-arch in *Mergus*, where the curve is continuous and unchecked by the presence of a hypocleidium.

The bone is, as a whole, slightly curved backward, so each limb presents a convexity to the front; these become broader and laterally compressed as we pass in the direction of their free extremities.

Either head very gradually tapers off to a point, and these produced ends ride over the scapulæ when the arch is articulated.

Projecting from their upper borders we find a single distinct and vertical process of bone that is quite characteristic. In the Eider this is in cartilage, but otherwise the fourchette is formed in this Duck very much the same as in the Merganser. (Fig. 14.)

In a *coracoid* we find the summit of the bone much produced above its articulation with the scapula, and compressed in the same plane with the shaft below it in such a manner that when articulated with the sternum the front of the bone is directed forward and outward.

The sternal extremity of the bone is very much expanded, and it also is found in the same plane with the general compression of the shaft.

Behind it is scarred by muscular lines, and shows a large luniform facet for the groove on the sternum.

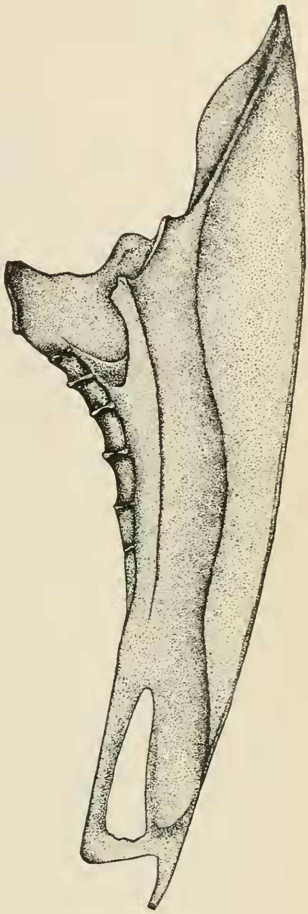

FIG. 4. Sternum of *Mergus serrator;* right lateral view; life size. By the author, from specimen 16626, Smithsonian collection.

The scapular process of the coracoid is to a great extent aborted; its superior margin being insufficient to accommodate the entire width of the scapula.

Nothing of importance distinguishes the glenoid cavity, it being formed, as in most birds, in the proportion of one-third on the part of the scapula and the remainder by the bone under consideration.

The *scapula* is much arched, and nearly of an equal width the entire length of its blade, its apex being rounded off. We find the bone considerably compressed in the vertical direction throughout, and the length of the chord measured between its extremities less than the length of the coracoid.

Of the pelvis and caudal vertebræ.—In order to better illustrate the fact that the pelvis in the Mergansers is constructed upon the same plan as that bone in other anserine birds, I have contrasted it, in Figs. 7 and 8, with the pelvis of the American Eider Duck. It will be seen at a glance that all the characters present in the latter are also to be found in *Mergus*, simply somewhat modified in concordance with its life as a diver.

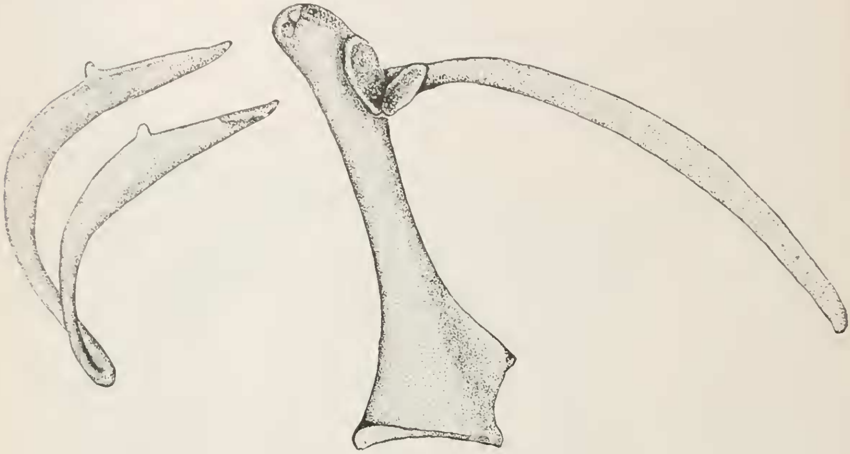

Fig. 5. Left scapula and coracoid, with furcula detached, *Mergus serrator*; life size. By the author, from specimen 16626, Smithsonian collection.

The ribs of the first three vertebræ that anchylos in the sacrum have already been described when speaking of these bones in general. Next to them we find that the three succeeding vertebræ throw out their apophyses to the pelvis and firmly anchylos therewith. After them we fall into the deep and oblong pelvic basin possessed by this bird, and the next three vertebræ send their processes directly upward. They are followed by a series of eight more that gradually approach the free caudals in form. The anterior one of these has the strongest lateral processes, but they are found to abut against the ilia on either side at a point anterior to the middle of the ischiac foramen, and not right behind the cotyloid cavities as in many other birds. The inner margins of the ilia anchylose with the outer ends of these sacro-vertebral apophyses, from the acetabula, backward, excepting the last one.

Opposite the cotyloid cavities we find the enlargement to accommodate that part of the spinal cord where the sacral plexus is thrown off; the openings for the exit of the latter are double, being placed one above the other.

Viewing this pelvis of *Mergus serrator* from above, we always find, jutting out in front, a tuft of bony spiculæ that form a part of the same system that strap the dorsal vertebræ together.

The inner margins of the ilia meet and anchylos with the top of the common neural spine of the leading vertebræ, converting the ilio-neural grooves into canals.

Each preacetabular portion of an ilium is much shorter than its postacetabular part, and also on a very much lower level. In front its border is emarginated, transversely truncate, and somewhat serrated. The surface of the bone is concave, and for the most part looks upward and outward.

Behind the acetabulum most of the ilium is devoted to the lateral aspect of the pelvis.

Turning to this side of the bone, we notice a pro-pubis of considerable size in front of the cotyloid ring, while the post-pubic element is a long slender rod, extending directly between the under side of the obturator foramen and the postero-external angle of the ischium, with which it articulates. Beyond this, it trebles its width and curves rather abruptly toward the fellow of the opposite side. A very narrow, open strait connects the obturator foramen and the obturator space; the former being rather smaller than usual and the latter very large.

The lower margin of the ischium is concave downward and very sharp, while the posterior border of the pelvis, formed by both the ischium and ilium, is perpendicular to the long axis of the bone. It shows one or two indentations that are not to be found in the same pelvic border of the Eider.

The acetabulum is large, with its inner and outer rings nearly of the same size; an antitrochanter of moderate dimensions stands between it and the antero-superior margin of the large elliptical ischiac foramen.

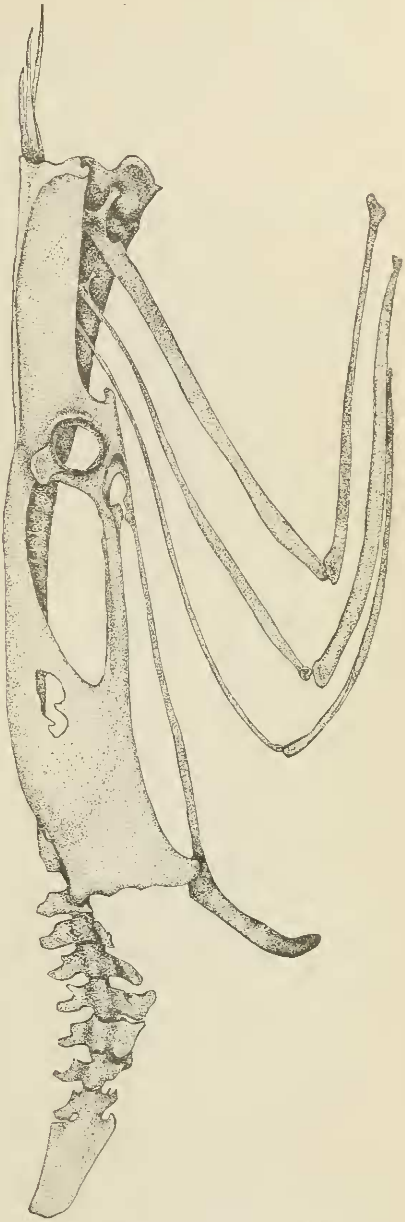

FIG. 6. Right lateral view of pelvis, caudal vertebræ, and sacral ribs of *Mergus serrator*; life size. By the author, from specimen 16626, Smithsonian collection.

Posterior to this latter aperture the ilium rises as a smooth dome

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above its own postero lateral plane and the ischium which lies below it.

In the present specimen this convexity shows a large fenestra in either ilium at its anterior part. No such vacuity exists in the Eider nor other Ducks in my possession. In some specimens the bone in the same locality is so thin that I expect it occasionally occurs in those birds also.

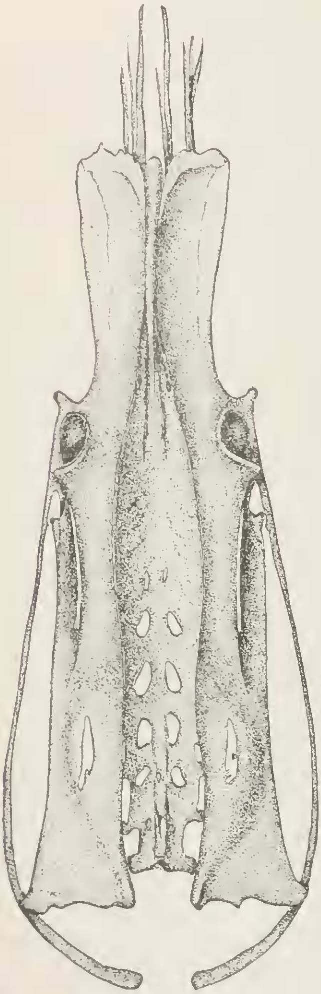

FIG. 7. Pelvis of *Mergus serrator*; viewed from above. (Specimen 16626, Smithsonian collection.)

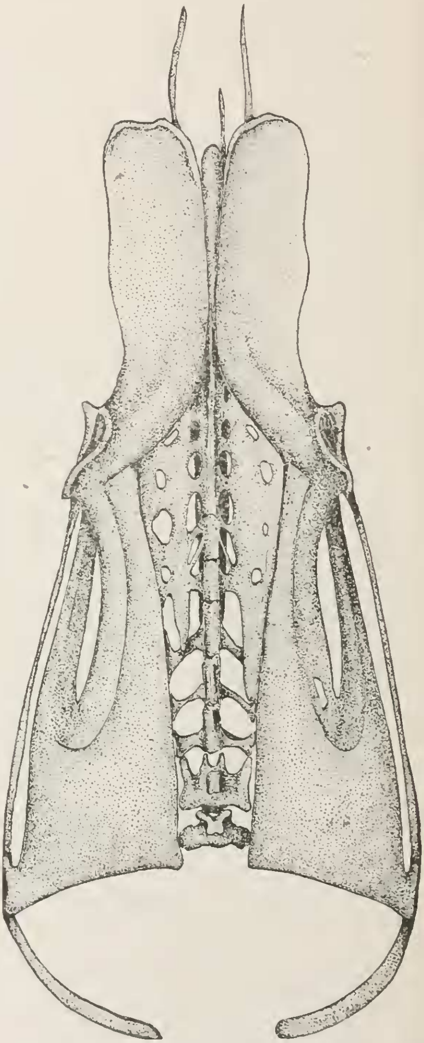

FIG. 8. Same view of pelvis of *Somateria dresseri*. (Specimen 16989, Smithsonian collection.) Both figures life size. By the author.

As already stated there are seven free *caudal vertebræ* and a pygostyle. The neural canal passes through all of the former and a short distance into the latter. Above it the neural spines are notched in front, and have an elevated, stumpy process behind.

The ends of the shortened diapophyses of the first free caudal are usually overlapped by the ilia, but in the next segment these processes are much longer, to be longer still in the third and fourth vertebræ. In the next two they again become shorter, to be entirely abortive in the ultimate one. In all they are broad and depressed.

Chevron bones are freely articulated between the centra of the last three or four vertebræ of the tail; they are bifid in front and grow gradually smaller as we proceed in that direction.

The pygostyle is here of considerable size, being an irregular quadrilateral figure, with its lower margin thickened, and all the others thin and cultrate.

Of the appendicular skeleton; pectoral limb.—When the skeleton of the upper extremity is in a position of rest alongside the body, we find that the humerus is somewhat longer than the bones of the antibrachium, and the pinion also projects beyond them behind to the full extent of the last phalanx of index digit.

The *humerus* is characterized by a broad, proximal extremity, showing an enormously deep pneumatic fossa, and a distinct trench between the ulnar crest and articular head, running beneath the latter. Its cylindrical shaft shows the usual sigmoid curves from radial and anconal views. Nothing unusual marks its distal extremity, where we find the trochlear tubercles for radius and ulna.

These latter bones are non-pneumatic, in common with the remainder of the skeleton of this limb. The shaft of the *radius* is straight, whereas it is curved in the *ulna*, the concavity occurring on the side toward the interosseous space.

The cylindrical shaft of this latter bone is faintly marked by a double row of papillæ for the secondaries.

In the *carpus* we find the two usual segments of forms common to the majority of the class.

In the pinion the bones are all remarkably well developed. *Carpometacarpus* has its main shaft straight and of a caliber intermediate between those of the antibrachium, or larger than the shaft of radius and smaller than the shaft of ulna. First metacarpal is short and anchylosed in the usual manner to shaft of index. The long trihedral pollex phalanx bears a distal joint, which is also the case with the second phalanx of index digit.

All the bones of the *pelvic extremity* are non-pneumatic, though the principal long ones have sizable medullary cavities.

The *femur* has a very large head, which rises somewhat above the broad articular summit of the shaft, notwithstanding its crown is considerably excavated for the ligamentum teres. The axis of its neck makes an angle with the axis of the shaft.

Trochanter major is suppressed above, while on the anterior aspect its thin edge partly surrounds a sort of fossa, where in other birds the pneumatic orifices occur. Its shaft is rather compressed from side to side and bent very slightly in the anterior direction. About its middle, on the posterior aspect, there is a prominent muscular tuberosity, and other lines or scars for muscular insertion are evident. Of the condyles the outer one is the lower, and it is profoundly cleft for the fibular head.

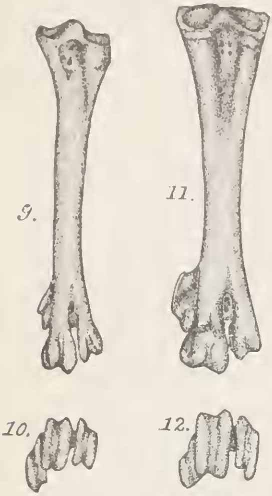

FIG. 9. Left tarso-metatarsus; anterior view, *Mergus serrator*. (Specimen 16626, Smithsonian collection.)

FIG. 10. Same bone seen from below.

FIG. 11. Corresponding bone from *Somateria dresseri*. (Specimen 16989, Smithsonian collection.)

FIG. 12. Same bone as Fig. 11, seen from below. All these figures life size. Drawn by the author from the specimens.

The popliteal depression is represented by a characteristic conical pocket just above the internal condyle on the posterior aspect. The rotular channel in front is also deep, but does not extend up the shaft a great distance.

From this same specimen I have illustrated the patella of this Merganser elsewhere (Proc. U. S. Nat. Mus., Vol. VII). It is seen to consist of two segments, with an oblique groove in the cartilage connecting them. Through this the tendon of the ambiens muscle passes.

Tibio-tarsus has a straight shaft that, unlike the femur above it, is somewhat compressed from before backward. At its proximal extremity we find a cnemial process reared above its articular surface for the femur. Prominent cnemial ridges occupy the anterior aspect of this, as usual. Of these the procnemial ridge is the higher and extends the lower on the inner side of the shaft.

The distal end of tibio-tarsus presents nothing peculiar. The groove anteriorly is deep, and the osseous bridge that spans it is thrown directly across. The external condyle is the broader in front, and its outer aspect is in the same plane with the side of the shaft, while the corresponding surface of the inner condyle lies beyond the plane of the shaft, for its own side.

Behind, these condyles still continue to be parallel to each other, but separated by an intercondyloid concavity that from its shallowness is scarcely worthy of the name, while the condyles themselves really merge into a broad, articular surface in this locality.

The *fibula*, when articulated, is found to rise above the summit of the tibia and project beyond it posteriorly. Its head is compressed from side to side, which gives it a very short, transverse diameter, while its antero-posterior one is fully three times as long. The articulation with the fibular ridge on the side of the tibio-tarsal shaft exceeds in length that portion of the bone that projects above it, and equals in length the slender portion that is found below. The connection between the bones along this ridge is of a ligamentous nature, and the distal fibular end seems to be attached pretty much in the same way to the side of the tibial shaft. This latter articulation occurs at a point about the unction of middle and lower thirds of the shaft of the larger leg bone.

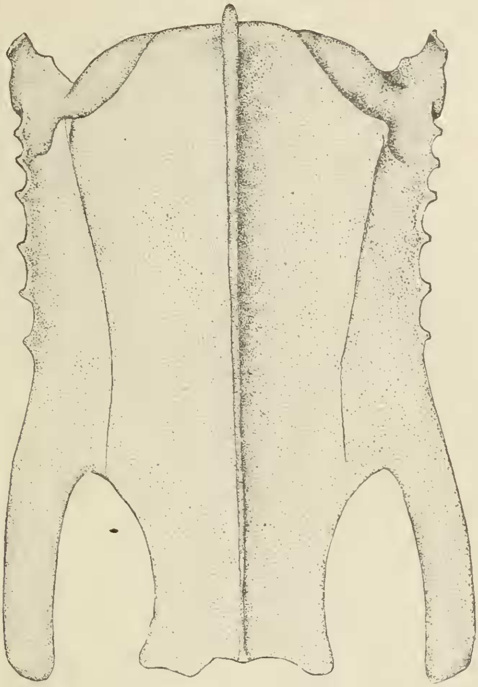

FIG. 13. Sternum of *Somateria dresseri*; pectoral aspect. (Specimen 16989, Smithsonian collection.) By the author. Life size.

With the exception of its proximal fourth, the *tarso-metatarsus* is considerably compressed from side to side, much in the same way as we find it in the *Urinatoridæ*. and to the same end.

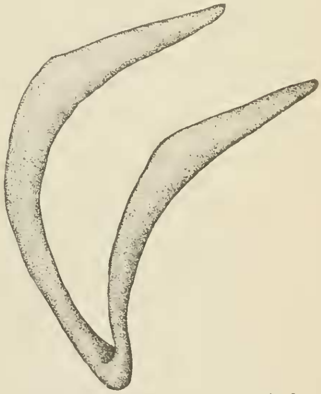

FIG. 14. The *furcula* of *Somateria dresseri*; life size. (Specimen 16989, Smithsonian collection.) By the author.

In order to show that this is simply another example in the skeleton of this Merganser of a physiological adaptation of structure to meet a certain requirement demanded on the part of its habits, I have, in Figs. 9 to 12, contrasted this bone, in two views, with the same bone taken from a specimen of the American Eider Duck, a bird far less noted as an habitual diver. It will be seen at a glance that fundamentally these two bones are essentially upon the same plan of structure, or, in other words, both are of an anserine type. The hypotarsus of this bone in *Mergus* consists of four vertical ridges—an inner large and longest one and three others of equal length. They form the grooves for the usual flexor tendons passing to the toes.

Notwithstanding their lateral compression, the trochleæ of the distal end are very large, their median grooves distinct, and carried all the way around. The inner trochlea is elevated upon the shaft, and only descends as far as the base of the middle one. It is also turned slightly inward, and at the same time projects the farthest behind. The usual foraminal perforation is seen in the furrow between the middle and outer trochleæ, just above the cleft that divides them.

We find the *accessory metatarsal* of a moderate size and elevated far above the inner trochlear projection—not articulating with the shaft of the tarso-metatarsus, as in many birds, but attached to a ligamentous structure stretching between the lower part of the hypotarsus and the trochlea above mentioned.

The hind toe which it supports is fully developed, with basal joint and claw, though it is proportionately much smaller in comparison with the three anterior toes with their large joints.

These latter need no special description, they are articulated and fashioned as in the anserine fowl generally, as well as being conformable with the most usual arrangement in regard to number of joints allotted to the several toes. We may fancy that a certain amount of lateral compression is present in the phalanges of these podal digits, but if it is so, it is very slight, being little more in degree than is enjoyed by like skeletal parts in the feet of the *Anatinæ*. To present the characters of the skeleton of the *Anatinæ* more in detail, I have chosen for the purpose a specimen of the common Spoon-bill Duck (*Spatula clypeata*) and will now rapidly review its osteology.

OSTEOLOGY OF SPATULA CLYPEATA.

So far as its skeleton goes this bird is very closely allied to the Teals, a fact that perhaps might not be suspected on first sight from external appearances alone. Beyond its increase in size, the chief point in departure from this genus is seen in the enormous development of the premaxilla and a corresponding enlargement of the mandibles (Figs. 15 to 18, *Pmx.*).

In the dried and properly prepared skull of *Spatula*, this premaxilla is an elegant, symmetrically formed, yet delicate scroll of bone, and, so far as I am aware, unequaled by any similar structure among vertebrates. At the middle part of the anterior arc there occurs a thickening, which in life supports the "nail" of the integumental sheath. Both this and the region on either side is quite thickly studded with foramina.

The external narial apertures are placed well back, as may be seen in Figs. 15 and 16, they being of a subelliptical outline. Comparatively speaking, these openings are considerably larger in the Swans and Geese, while in such a form as *Glaucionetta islandica* they relatively occupy a mid-site on the mandibular side, the nasal being a broader bone. I have figured a side view of the skull of this latter Duck in Coues's "Key," second edition, where this feature may be seen.

Spatula and the Teals always have the extremity of the nasal median processes of the premaxillary remain distinct to a large extent in the cranio-facial region throughout life (Fig. 16). This is also well shown in the Mallard, less so in *Olor*, and barely observable in Hutchin's Goose.

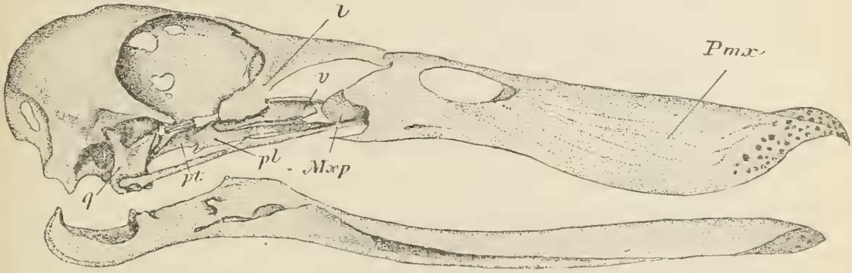

FIG. 15. Right lateral view of the skull of *Spatula clypeata*, ♂; life size. From a specimen in the author's cabinet, and used throughout this article where this form is figured. *l*, lachrymal; *Pmx*, premaxillary; *q*, quadrate; *pt*, pterygoid; *pl*, palatine; *Mxp*, maxillo-palatine.

Mobility of the cranio-facial hinge, however, does not seem to depend upon this condition, for in *Glaucionetta*, where a considerable amount is enjoyed, this individualization of the nasal processes of the premaxilla does not obtain to such a marked extent.

Confining ourselves for the present to the lateral aspect of the skull (Fig. 15), we find a notorious anatidine character very pronounced in *Spatula*, and this is the enormous development of the lachrymal (*l*) and the consequent antero-extension of the lachrymo-frontal region.

The descending process of this bone reaches backward toward the long sphenotic apophysis, nearly to touch it in *Glaucionetta*, in which Duck it usually lacks the terminal dilation so prominent in our subject, and still more so in the Swans. The interorbital septum rarely shows any deficiencies in its bony plate, the Golden-Eye being the only form in which I have met such a condition, and in this fowl it is very small. In all *Anatidæ* the osseous pars plana seems to be aborted, simply a low, bony ridge indicating where it is developed in other birds. The mesethmoid is developed, however, as a strong median abutment extending far forward beneath the cranio-frontal region.

A vacuity usually occurs throughout the group, high up on the posterior orbital wall, though the foramen for the exit of the olfactory nerve is not notably large, and the one for the optic is distinct from the outlying smaller nerve apertures about it.

Most Ducks and the Brant have the track for the passage of the olfactory to the rhinal chamber an open groove, while in *Olor* it may be practically overarched by bone.

As already intimated in a former paragraph, *Spatula*, in common with others of the suborder, had a greatly lengthened sphenotic or post-frontal process, while the squamosal projection would hardly attract attention in any of them.

The infraorbital bar is long, nearly straight, narrow, and much compressed from side to side. On its upper edge beneath the lacrymal a little papilli-form elevation is usually seen. Its quadrate extremity is slightly tilted upward before it sinks into the pit in that bone. This upward deflection is best observed in the Swans, not being well marked in our Broad-bill. The maxillary (*Max*) extremity of the bar is in all firmly wedged in between the palatine and the dentary process of the premaxilla, being completely fused with these bones in the adult.

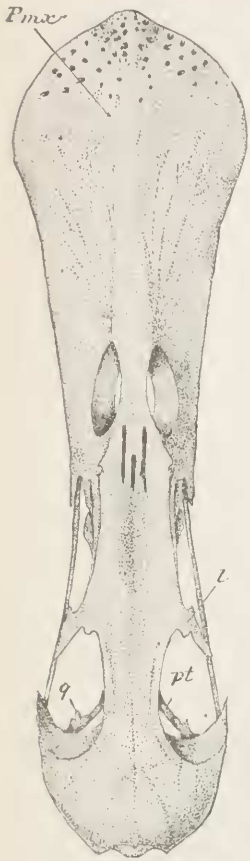

FIG. 16. Skull of *Spatula clypeata* seen from above; mandible removed; life size. Letters as before.

Anatidæ as a rule, and *Spatula* form no exception, possess a large and massive *quadrate*. This bone has in them a broad and subcompressed body of a quadrilateral form, to the antero-superior angle of which a spine-like orbital process is superadded and rather deflected toward the median plane. The mandibular foot of this element supports two elongated facets, placed side by side with their major axes extended in the transverse direction. The inner of these facets is always the smaller.

At the mastoidal extremity of the quadrate we find a globular head, fairly divided in two by a shallow groove running from before backward. This articular end is well incased by the surrounding bone.

The quadrato-jugal and pterygoidal articulations require no special mention, they being much as we find them in a number of other water fowl.

Anatidæ have the lateral aspect of the cranium smooth and evenly convex, while lower down a shallow and vertically elongated crotaphyte fossa can generally be pretty well made out. I find it least pronounced in Hutchin's Goose, while it is quite strong in the Garrot. In all cases it is produced downward upon the highly developed temporal wing, which forms the back part of the bony ear-conch. This latter is conspicuous in having, in most Ducks, incurling margins to protect it. These latter are not so manifest in the Geese, and they are absent entirely in *Olor*.

In Fig. 16 we have an upper view of the skull of *Spatula*, and this permits us to gain a very good idea of the enormous development of the premaxilla (*Pmx*).

The fronto lacrymal region we observe to be unusually elongated, and in this form concaved in a longitudinal median direction. This latter feature obtains also in the Mallard and the Teals, where it is quite as well marked, while, on the other hand, in the Swans, Brant, and Geese this fronto-lacrymal region is not so strikingly lengthened, being flat in some of the latter and mounded up in some *Cygninæ*.

The space between the orbital margins on this aspect shows considerable width, more particularly in such forms as *Glaucionetta*, where it is marked by a longitudinal median crease.

The supraorbital glandular depressions for the nasal glands, so prominent in many of the Auks and other water fowl, are here in the *Anatidæ* rarely well marked.

In *Spatula* they consist in a very narrow trimming off of the edge of the orbital peripheries, barely perceptible in the Mallard and *Anas carolinensis*. In *Glaucionetta* they are better developed, but in this Duck they are really moved down so as to form one of the features of the lateral aspect of the skull (Fig. 63, *w*, Coues's "Key," 2d ed.). They are quite well marked in the Hutchin's Goose.

Spatula, *Anas boschas*, and the Teals have a strongly incised notch on either side, at the anterior arc of the supraorbital rim, which seems to define the posterior ending of the lachrymal bone. It is absent in the Garrot, but again characteristic in Swans and Geese.

The vault of the cranium behind is, upon this aspect, usually smooth and rounded. A longitudinal crease may pass it in the middle line, and elevations on either side in some forms (*Spatula*, *Olor*) faintly indicate the divisions of the encephalon within.

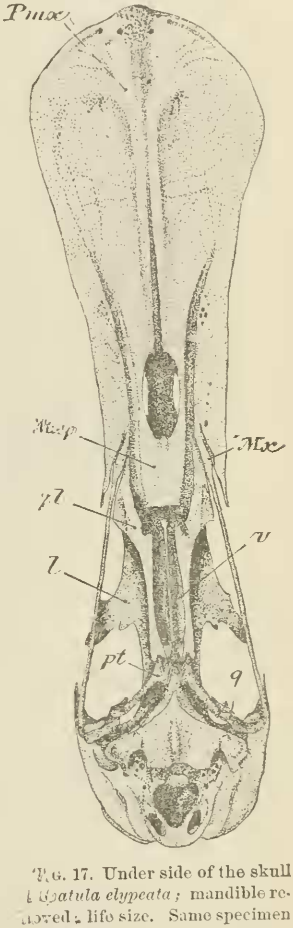

FIG. 17. Under side of the skull of *Spatula clypeata*; mandible removed; life size. Same specimen with *Mxp*, maxillo-palatine, and the other letters as before.

Turning now to the under view of the skull of the Spoon-bill, we are to note the great concavity of the premaxillary, with its sharply-defined parial gutters for vessels and nerves and their ramifications.

As is well known, all the *Anatidæ* exhibit the typical desmognathous arrangement of the palatal bones. The maxillo-palatines unite in the middle line to form a large bony mass (*Mxp*), in front of which there occurs in all the Chenomorphæ, that I have been enabled to examine, a more or less cleanly cut elliptical opening, the remnants of a much greater vacuity of other birds. In the Swans these maxillo-palatines are quite spongy; in *Branta canadensis hutchinsii* they unite with a firm lamelliform nasal septum that makes a long abutment against the roof of the rhinal chamber above. This nasal septum is entirely absent in *Spatula*, and illy developed in *Anas carolinensis* and the Mallard.

My drawing of the basal view of this Duck illustrates Coues's "Key," (Fig. 78), where the above points may be compared with advantage.

In *Spatula* (and the arrangement, with a few unimportant minor differences, holds good for the group) the palatines (*pl*) are horizontally compressed at their anterior ends, where they form anchylosed schindylesial articulations with the premaxilla and maxillaries, as already described. The body of one of these bones is slenderer along its middle length, separated by a wide interval from its fellow, and half the distance from the vomer (*v*).

Its "ascending process" is short, and is carried along the upper vomerine margin, where it unites with the opposite palatine to form a lon-

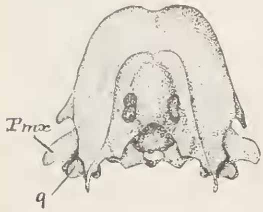

FIG. 18. Rear view of skull of *Spatula clypeata.*

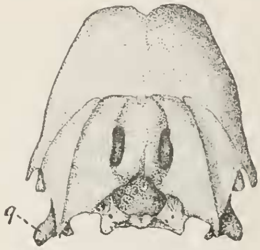

FIG. 19. Rear view of skull of *Glaucionetta islandica*. Both figures lite size, from the specimens. Mandibles removed. Letters as before.

gitudinal, rib-like re-enforcement along the upper edge of that bone. It is only in this situation that the anserine palatines meet each other.

The joint that one of these bones makes with the corresponding pterygoid (*pt*) is a sort of mortise-and-tenon arrangement that very perfectly meets the requirements of the parts involved.

The palatines barely escape resting against the under side of the rostrum of the sphenoid, which passes immediately above them. This is true of all the *Anatidæ* so far as I have seen.

As to the vomer (*v*) proper, we find it to be a thin lamella of bone in the median line, supported, as pointed out above, by the rib on its upper margin developed from the ascending processes of the palatines. This portion is carried forward by a thickening of the vomer itself, somewhere beyond its middle, as a protuding spine like anterior process.

This spine usually rests in a groove formed by the union of the maxillo-palatines behind, though in the skull of a female Mallard before me not only this projection, but a good share of the vomerine plate has fused with this maxillo-palatine mass in part, to become immovably connected with them.

The lower margin of the vomer is sharp, and the whole plate is gently arched in such a manner as to make the upper edge convex along its continuity, the reverse obtaining below.

When speaking of the palatines I neglected to invite attention to the notch found on the inner margin of either one of them about opposite the anterior termination of the vomerine plate. This notch is converted into a foramen in the Mallard, and entirely absent in Hutchin's Goose and the Whistling Swan.

Spatula possesses a pterygoid (*pt*) of the same general form it assumes in any of the *Anatidæ*. Its shaft is short and straight, while its anterior end is much enlarged, first, by a descending lamina of bone developed upon it and, secondly, by the large sessile, elliptical facet on its opposite side for articulation with a similar facet on the sphenoidal rostrum. Anterior to this facet the pterygoid develops an upturned process of spine-like dimensions, which, when the bones are *in situ*, is closely applied to the back side of the ascending process of the palatine. Below this process the pterygoid is deeply and roundly notched to receive a peg-like projection on the palatine, which movably fits into it.

The projecting and rounded postero-external angle of the palatine extends below this pterygoidal articulation.

Generally the lower border of the rostrum is rounded; it is very broadly so in Brant, though it becomes quite flat in *Glaucionetta*; there it may be carried forward as a projecting process.

The anterior ethmoidal edge is always sharp, sloping forward and upward to become a median crest on the under side of that part of the bone which abuts against the frontal region for its entire length.

In *Spatula* the basitemporal region is quite broad, and marked by a median and rounded ridge. This is carried out upon the pointed lip of bone that under-laps the double entrance of the Eustachian tubes in front. A decided dimple is found in front of the sessile and superiorly notched occipital condyle, while the foramen magnum is large, of a cordate outline, with its apex directed upward.

Laterally we find the descending temporal wings, with the usual group of foramina to the inner side of each, at the base of quite a well-marked little fossa.

The plane of the foramen magnum makes an angle of about 45° with the backwardly produced plane of the basis cranii.

A posterior aspect of the skull of this Duck (Fig. 18) shows a conspicuous supraoccipital prominence, with a large, vertical, and elliptical foramen opening into the cranial casket on either side of it. The occipital area is well divided off from the crotaphyte fossæ by a raised ridge which surrounds it. These last-named depressions are separated in the median line by quite an extensive interval. I believe they never meet in any true Duck.

This description of the cranial base and posterior aspect of the skull in the Spoon-bill practically answers for the Mallard and the Teals, though, of course, slight differences do exist.

In *Glaucionetta islandica* the basis cranii is proportionately flatter; the temporal wings less manifest; a separate ridge bounds the fossa for the nerve and arterial foramina externally, and the condyle is more prominent and its superior median notch very deep. The vault of the cranium is very lofty in this Duck (Fig. 19), and the ridge bounding the occipital area almost crest-like.

Speaking of the unusual height of the cranial vault in the Garrot, we find this bird very peculiarly constructed in this particular, for not only is the brain case of a size above the average for the group, but a curious and not inconsiderable diplöic cavity overlies the whole top of the skull, extending as far forward as the mesethmoid. Here it is interrupted by a pair on either side, one in front of the other, of deep and sharply defined chambers, with their apertures facing directly downward. This condition is not so pronounced in a young female *Glaucionetta*, a specimen of which I have before me.

Branta has a very large brain-case, and upon the under side of the skull of a specimen of *B. canadensis hutchinsii* we note that a quadrate has an area of no mean size, and nearly horizontal, extending to the rear of its mandibular facets. In this Goose, too, we find a very broad and flat basi-temporal area, with the shield to the entrance of the Eustachian tubes nearly aborted. These latter appertures are wide apart at the situation usually protected by it. The temporal wings are feebly developed in comparison with the *Cygninæ*, and the occipital condyle is almost pedunculated. The group of foramina to its inner side of either temporal wing is situate at the base of a well-defined fossa specially designed to receive them.

Finally, we observe that the form of the foramen magnum is more elliptical in outline rather than cordate, as we found it in the Ducks. Above it the supraoccipital prominence is very conspicuous, while the foramina on either side of it may or may not exist.

In the skull taken from a magnificent male specimen of *Olor columbianus** I find the basi-temporal triangle comparatively very small, with the dimple anterior to the condyle deep and having parial ones placed side by side in front of it. The descending temporal wings are enormously developed, each one overshadowing a considerable excavation to its inner side.

The condyle is relatively smaller than it is in the Geese, and its superior notch not so well marked, while the foramen magnum is quite circular in outline. Elliptical vacuities may or may not exist at the sides

* I am greatly indebted to the generosity of Mr. G. Frean Morcom, of Chicago, for this present. The bird was forwarded to me by Mr. Morcom from Chicago to Fort Wingate, N. Mex., by express. It arrived in excellent condition in the flesh, and the fine skeleton it afforded me has been of the greatest service in the present connection. When this memoir is published it is my intention to present the specimen to the Smithsonian Institution at Washington as a type.—R. W. S.

of the fairly well-pronounced supraoccipital elevation. The plane of the occipital area is nearly or quite perpendicular to the plane of the *basis cranii*.

Anatidæ have their skulls more or less perfectly permeated by air, and when properly prepared are really structures of great beauty, as is the glistening white skull of the Swan before me, which is so exceedingly light for its size and withal so graceful in outline.

Few and unimportant are the differences that are found to exist between any two *mandibles* of representative *Anatidæ*, the general type of the structure being quite a uniform pattern, as it prevails throughout the entire group. Perhaps *Spatula* offers us as great a departure from the common form of the anatidine mandible as any American Duck we have, and even here we find, on side view, that it possesses all the essential characters of the bone as found in the group. Seen upon this latter aspect we have presented us for examination the lamelliform and vertical angular processes. These are greatly produced directly backward, to be abruptly recurved upward at their extremities. This is the style also in *Olor*, but in Hutchin's Goose they are saber shaped and gradually recurve upward. Beyond this process the articular facet projects from the ramal side, and at a varying distance (for the species) in front of this we find a constant process for muscular attachment. This last is situate at about the middle of the deepest and most plate-like portion of the ramus, and in a Swan is ridge-like, being connected with the coronoid process on the edge of the bone immediately above it.

In front of this the ramal vacuity—a narrow slit—is usually completely closed by the splenial element.

The bone now becomes shallower in the vertical direction, its superior and inferior borders rounded, while a well-defined gutter for the passage of nerves and vessels marks its entire length.

As a rule, among the *Anatidæ* the symphysis is rather deep, rounded beneath, and correspondingly concave above, the under side being thickly studded with vascular foramina. *Spatula* has a somewhat different anterior ending from this, as is shown in Fig. 20.

In the middle line in front a sort of "nail" is developed like the one found on the superior mandible, though not so strong. The superior ramal margins are continued round this projection, forming its edge, while the spoon-like dilatation is insured by the outer ramal sides shelving away from this upper border, so as to face upward and outward rather than directly outward, as they do posteriorly.

FIG. 20. Mandible of *Spatula clypeata*; seen from above; adult ♂; life size, from the specimen.

The form most common for the mandible to have, as viewed from above, is well exemplified in *Glaucionetta*, as shown in Fig. 21, which presents this aspect of the bone in the Garrot.

The articular projections lie nearly in the horizontal plane, and each one supports the two concavities for the mandibular foot of the quadrate. A rather slender intwined process directed upward and toward the medial plane projects from the inner one. This may present a small pneumatic foramen at its extremity. Beneath either of these articular portions of the mandible, and to the inner side of the angular process, we discover a deep conical fossa, with its apex to the front.

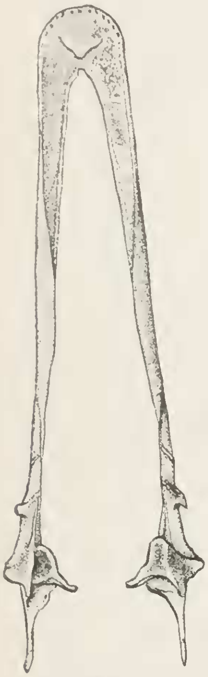

Fig. 21. Mandible of *Glaucionetta islandica*; seen from above, adult ♂; life size; from nature.

It is intended for muscular insertion, and is present, I believe, throughout the group.

The mandible is very imperfectly pneumatic, particularly in the Brant, where the bone sometimes, if not always, entirely lacks this condition.

For the general form assumed by the *hyoidean apparatus* in these birds the reader is referred to my figure of these parts as they occur in *Branta canadensis*, in Coues's "Key," second edition, on page 167 (Fig. 72).

Here we find an elongated elliptical piece in front, of some width, which represents the glossohyal and absorbed ceratohyals. It develops a median facet anteriorly for articulation, with a cartilaginous rod, which passes into the soft part of the tongue proper.

This glossohyal is longitudinally concaved beneath and correspondingly convex above; it articulates with the fused basi-branchials, the first one of which is by far the stouter element, the second almost spiculiform in its dimensions, and produced by a cartilaginous tip behind.

The thyrohyal elements consist each of the two usual parts, and these greater cornua curl up gracefully behind the skull, after the fashion of the class generally.

Without entering upon details, I find after careful comparison of a sufficient number of skulls, that of the Teals, the Blue-winged species (*A. discors*), more nearly approaches *Spatula* than any of that genus, while, on the other hand, a very close resemblance is seen to exist between the skull of *Spatula* and that of the Mallard, the most evident points of difference in these last being the shape of the premaxilla and the more robust type of skull possessed by the Mallard. With but very few exceptions, I believe I have shot every species of Duck in this country, yet, at the present writing, I regret to say that I have not at hand the skulls of the genera *Dafila*, *Anas strepera*, nor *Anas penelope*, and it will be very interesting to compare these forms on some future occasion with those described in the foregoing paragraphs.

It is a well-known fact that the number of vertebræ in the spinal column of the *Anatidæ* is by no means constant. Even genera supposed to be quite nearly related may differ in this particular, so that careful records in this direction are very much needed, and when a sufficient number have been taken to insure absolute accuracy such data will be of service.

In the subjoined table I have but little to offer, but it is the result of a careful count in each case, and will go to show some of the differences referred to and the method of comparison.

Species.	Number of vertebræ in cervical region without free ribs.	Vertebræ that bear free ribs not reaching sternum.	Dorsal vertebræ (inclusive).	Vertebræ consolidated with pelvis (inclusive).	Free caudal vertebræ (to which pygostyle is to be added).
Olor columbianus	22	23d	24th to 28th	29th to 45th	46th to 52d.
Spatula clypeata	15	16th	17th to 21st	22d to 37th	38th to 44th.
Anas discors	15	16th	17th to 21st	22d to 37th	38th to 43d.
Glaucionetta islandica	15	16th and 17th	18th to 21st	22d to 37th	38th to 43d.

Now, in the case of *Spatula* and *Glaucionetta*, in the specimens before me, the thirty-eighth vertebræ, though free and really a caudal, lies within the grasp of the hinder ends of the iliac bones, whereas in the Teals this segment is found one vertebra's length behind them or entirely without their grasp. It will be seen, however, that this does not affect the total count, it remaining forty-four for the first-named genus and but forty-three for the Garrot. I mention this because specimens may yet be found where this thirty-eighth vertebra has united with the pelvis, as from the position it occupies it is perfectly possible for it to do in the genera mentioned.

The general characters of these segments as they are exhibited by most Ducks are very well shown in *Spatula*.

The *atlas* has its cup perforated by the odontoid process of the atlas vertebra, and is characteristics in having the lateral canals—a feature, so far as I am informed at present, that is common to the Anseres.

An open carotid canal is provided for by the sixth to the twelfth vertebræ, after which a strong median hypapophysis takes its place, and this becomes tricornuted in the sixteenth segment and first dorsal, while in the eighteenth and nineteenth it is a long median plate.

The fifth and sixth cervical usually has the best-marked neural spine, which is there a long, though not high, median crest. The lateral canals in the first half of the cervical region are long and tubular, while the parapophyses are co-ossified for nearly their entire lengths with their sides. *Anatidæ* possess the "heterocœlous" type of articulation among the centra of the spinal column. A strong hypapophysis is found on the second and third cervical vertebræ, to be much reduced in the succeeding one, while the following segments in the skeleton of the neck are notably broad and rather long. In this region one thing is sure to attract our attention, and this is the brevity of the pre- and postzygapophyses, an arrangement which has the effect of very materially reducing the size of the intervertebral spaces or apertures.

In the dorsal region the vertebræ are not only locked together by their close-fitting neural spines, but a very extensive system of metapophysial and other bony spiculæ render the strapping still more efficient. The transverse processes are very wide, too, so that, notwithstanding the fact that these segments are all free, the mobility enjoyed by this division of the column is very much compromised. Pneumaticity is but very imperfectly extended to the vertebræ of the column, especially in the cervical region; while this is likewise true of the Swans, this condition in them is very much more complete, and their dorsal vertebræ are wonderfully well provided for in this particular.

The *ribs* seem always to be non-pneumatic, with large anchylosed unciform processes, being wide and flat in the body above the points where they are attached. *Glaucionetta* is notorious for both of these characters.

Spatula has on one side seven ribs that connect with the sternum by costal ribs; one pair behind these, where the hæmapophysis fails to reach that bone, and, finally, a small floating hæmapophysis clinging to the posterior margin of the latter. The last two pairs of vertebral ribs come from the sacrum and are without unciform processes.

This arrangement of the ribs prevails also in *Anas cyanoptera*, while in *Glaucionetta* the series leads off with two pairs of free ribs, one on the sixteenth and one on the seventeenth vertebra, the following six connecting with the sternum, and three pairs coming from the consolidated sacral vertebræ, making in all nine pairs of ribs to each side, the last three not bearing unciform processes.

In *Olor columbianus* the arrangement is again entirely different. Here we find the series leading off with one pair of free ribs (on the twenty-third vertebra), followed by *nine* pairs that connect with the sternum by costal ribs and completed by a purely floating pair that neither joins with the pelvis above nor the sternum below. This gives the Swan eleven pairs of ribs. Of these the first, and the last four are without unciform appendages. In those ribs where they do occur they are anchylosed to them and are not notably large. The last four pairs of ribs come from beneath the ilia in this Swan and curve far backward, reminding us of a condition that is still more pronounced in the Loons. Nor is this the only feature in *Olor* wherein it resembles that family, as we will see further on.

This Swan has a low median hypapophysis on each dorsal vertebra, and the neural crests of these segments are comparatively low, being laced together by long spiculæ, as we described them for the Ducks.

The skeleton of the tail is much as it is in *Spatula* and Teals, in which genera the diapophyses are wide and spreading, while beneath, the ventral apophyses are anchylosed to the centra upon which they occur and hook forward over the preceding vertebral body. The pygostyle in these and most forms of the group is somewhat elongated, of an irregular quadrilateral outline, with thickened posterior border.

Glaucionetta has very wide and spreading transverse processes to its caudal vertebræ, and the chevron bones upon the last two are free and rest mainly upon the intervertebral cartilage, as a greater series of them do in the Swans.

Turning our attention now to the consideration of the pelvis, we find this compound bone in *Spatula* presenting us upon its dorsal aspect the following points for our examination: The ilio-neural canals are completely closed in by the ilia meeting and anchylosing with the crista of the leading sacral vertebræ. This is the case, I believe, throughout the entire order. On either side of this the pre-acetabular portion of the ilium is longitudinally concaved, each anterior border being emarginated by raised bone and embellished with a few projecting spiculæ.

The post-acetabular sacral portion of the pelvis is in general in the horizontal plane, being pierced in an irregular manner by a few scattered and small interdiapophysial foramina, while a median furrow, deepest behind, marks its entire length.

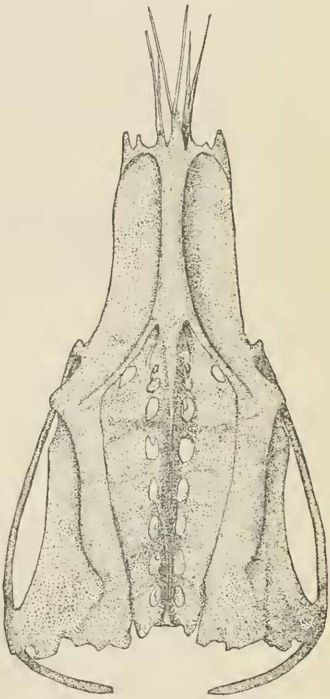

Fig. 22. Dorsal view of the pelvis of *Spatula clypeata*. Size of life.

From this part of the pelvis the sides slope gently away. The posterior margin is more or less unevenly notched; the notch indicating on either side, however, the point of union between ilium and ischium is constant both as to occurrence and location. So far as we have thus described the bone it will answer in general terms for the Teals, but in *Glaucionetta* the pre-acetabular area is notably shorter, while behind the bone is more spreading, the interdiapophysial foramina far more numerous and larger, and, finally, the posterior margin is nearly even. Upon the lateral aspect of the pelvis in *Spatula* we find rather a large cotyloid ring, surmounted at its upper and back part by a modest antitrochanter. The ischiac foramen is extensive and subelliptical in outline. Behind this we sometimes find, both in this species and in the Teals, a thin tract of bone, which thinning may be carried to the point of forming another foramen, or a post-ischiac foramen, which is quite large in some specimens,

March 26, 1889.

In all the *Anatidæ* that I have examined a pro-pubis is to be found jutting forward from its usual site. This is the case in *Spatula.* Behind this a small obturator foramen, nearly closed in, is to be noted, while the obturator space is very large and completely surrounded by bone behind, through the foot-like process afforded by the ischium. This latter projection articulates with a facet, intended for that purpose, on the upper border of the post-pubis.

The post-pubis is a slender rod as it passes beneath the obturator space, but after its articulation with the ischium posteriorly it has its width nearly doubled, and in *Glaucionetta* the hinder ends are slightly enlarged. This latter Duck departs from the above description principally in such a minor detail as having a relatively much larger ischiac foramen and longer obturator space.

In all of these species we find the pelvic basin upon the ventral aspect very capacious, both as to its depth and width.

As I have already stated elsewhere, the pelvis in *Olor* has a very different form from that bone as we find it in the Ducks. It assumes a shape that at once brings to our mind the mergine pattern, with its greater length as compared with its width; the almost entire disappear-

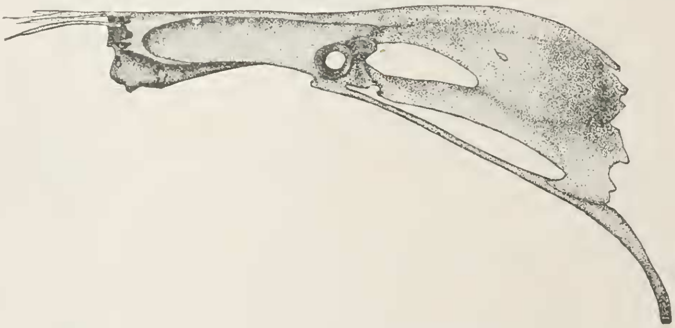

FIG. 23. Left lateral aspect of pelvis of *Spatula clypeata*; life size. Same specimen as Fig. 22.

ance of the interdiapophysial foramina, and the broad, paddle-shaped extremities of the post-pubic elements. This model sees its extreme modification in the *Pygopodes*; and if we remove the intrasternal chamber for the accommodation of the tracheal loop, we find in the sternum, too, of the Swan a great deal to remind us of that bone in *Urinator.*

Spatula possesses, in common with most Ducks, a completely non-pneumatic *shoulder girdle.* In it we find a broad, U-shaped furcula, devoid of hypocleidium and with its long, pointed, clavicular heads extending almost directly backward. On the upper side, where either of these latter merge with the limbs, we find a peculiar little peg-like process, that is quite characteristic of most *Anatidæ.* The scapula is long and curved, the curve being in the plane of its blade, with the convex border mesiad. Its posterior end is simply rounded off, and its head makes a firm articulation with the broad, scapular process of the coracoid.

This latter bone has its shaft much compressed from before, backward, while its sternal extremity develops an unusual expansion, the infero-external angle of which is truncated.

Anas discors agrees in its pectoral arch, in the main, with the one just described for the Broad-bill. It has, however, a rudimentary hypocleidium present.

This latter feature is entirely absent in *Glaucionetta*, where the furcula is very strong and its U very broad. Otherwise the bone is generally marked by all the characters it bears in the Ducks. The blade of the scapula in *Glaucionetta* is much arched, and shorter and broader than it is in the Teals. The coracoid presents nothing peculiar, having much the same form that it has in *Spatula*, though it agrees with the Teals in having a comparatively longer shaft.

Aside from its greater size, *Olor* possesses a scapula very like that bone in *Glaucionetta*. The Swan has its coracoid, however, very short and thick-set, and does not at once suggest to us its family relations, though a moment's study is sufficient to trace the modifications and resemblance. The unique form assumed by the furcula of this stately fowl is well known to us. Its clavicular heads are long drawn out to terminate posteriorly in sharp points. Moreover, the bone is highly pneumatic, the foramina being found well up on the outer aspect of either limb, in a longitudinal excavation that there occurs. These clavicular limbs gradually approach each other as they descend, and when they come close to and opposite the middle points of the anterior and vertical borders of the tracheal entrance to the sternum they are reflected upward, and unite as a U-arch in the median line just beneath the manubrium. The anterior aspect of this secondary arch is convex, while behind it is much concaved, especially at its highest point, where a small circumscribed pit occurs. The object of this modification of the fourchette in the Swan is to permit the tracheal loop that enters the carina of the sternum a passage-way, but the requisition of the entire arrangement is one of those problems in anatomy which, I believe, still awaits a final solution.

The *sternum* affords another instance of skeletal likenesses between

FIG. 24. Left lateral aspect of sternum of *Spatula clypeata*; life size. Same specimen as before.

the genus *Spatula* and the Teals; indeed, this bone in the latter genus is to all intents and purposes the perfect miniature of the sternum of the former Duck. On its dorsal aspect the bone is much concaved throughout and presents a single, median, pneumatic foramen just within its anterior border. This aperture, though a smaller one, is also seen in the Garrot, but the sternum of that Duck is a non-pneumatic one.

It will be observed from Fig. 24 that the sternum of the Spoon-bill possesses quite a prominent, peg-like manubrium, and that its sharp, anterior carinal border slopes to the front, forming an acute angle with the convex and ribbed inferior margin of the keel at their point of intersection.

This keel extends the entire length of the sternal body, and is withal rather a deep one. The usual swell that fortifies it in front is uncommonly broad. Above the manubrium, in front, the coracoidal grooves unite in the median line, and the common bed thus formed is carried out laterally, on either side, to a point opposite the middle of the base of the costal process. These latter projections are rather lofty and prominent, each being of a broad, quadrilateral outline.

Either costal border occupies less than half of the lateral margin, the remainder being somewhat curved and cultrate.

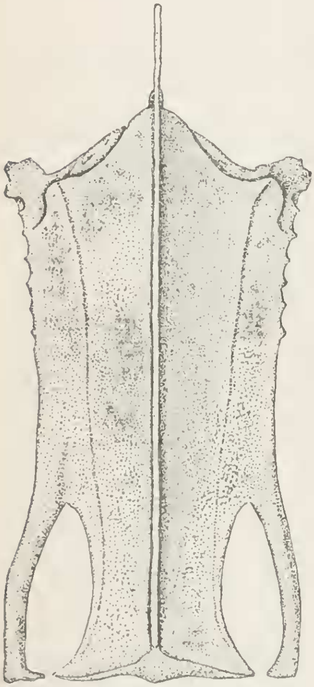

FIG. 25. Under view of sternum of *Spatula clypeata;* life size. Same bone as shown in Fig. 24.

Regarding this bone from a pectoral aspect (Fig. 25), we notice that the form of the sternal body is oblong, with a slight outcurving of the lateral xiphoidal processes behind. These latter form the external boundaries to the large subelliptical vacuities, one on either side of the hinder extremity of the bone; but they fail to convert these apertures into true fenestræ, from the fact that their inturned tips never reach the external angles of the mid-xiphoidal prolongation, as shown in the figure. This latter projection always has its posterior margin fortified by a raised and thickened edge, which is continuous with the rib of the inferior carinal border.

The principal muscular line seen upon either side of this wall of the sternum, extends directly from the middle point of that lip of bone which underlaps the outer end of the coracoidal groove, to follow the inner edge of the xiphoidal notch to the apex of the postero-external angle of the mid projection, traveling the entire length of the sternum, of course, to do so.

Now *Glaucionetta islandica* has a sternum of an entirely different form from the bone as I have just described it for *Spatula* and the Teals.

In the first place, its body is relatively much shorter for its width than it is in those Ducks, while in front the manubrial process has entirely disappeared. Again, the costal processes are loftier and more conspicuous. The xiphoidal extremity of the bone is very broad and is pierced well within its hinder margin, on either side, by an elliptical foramen, as shown in Fig. 26, where it will also be observed that the carina does not extend the entire length of the sternal body, but stops short at the

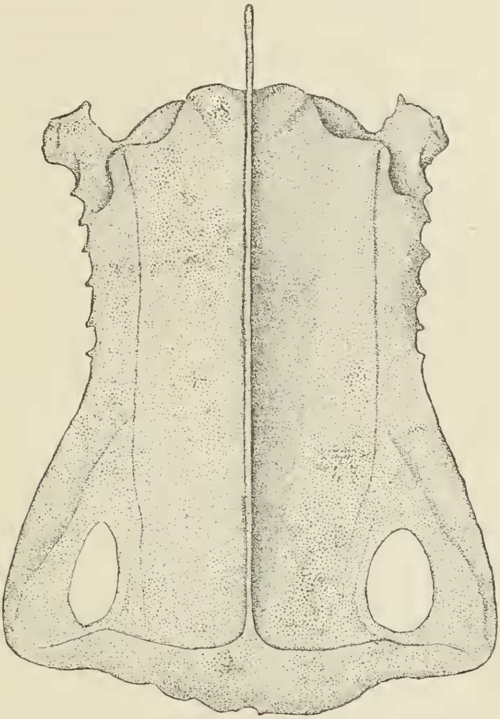

FIG. 26. Pectoral aspect of sternum of *Glaucionetta islandica*; life size. From a specimen in the collection of the author.

middle point of a raised line, that, being produced as it is, is tangent to the posterior arcs of the xiphoidal fenestræ.

The muscular lines take about the same course as they do in *Spatula*, with the exception that their posterior ends are inclined inward rather than outward, as in the form mentioned.

This form of sternum agrees in many particulars with the bone as we find it in *Mergus*, though in the Eider Ducks, as I have elsewhere pointed out, the xiphoidal extremity is deeply two-notched.

Such differences certainly are significant, and must be awarded their due share of weight in the search for affinities among the several forms of this order, and it will be interesting to find with what similar characters they are associated.

Another engaging subject in the anatomy of the *Anatidæ* is the study of the various forms taken on by the osseous labyrinth at the bifurcation of the bronchi. This is of a very unique shape in *Glaucionetta*, and I have figured a specimen of it as it occurs in this Duck in Coues's "Key," showing the development from behind (second edition, Fig. 98).

It is my intention, on some future occasion, to make a thorough comparison of these tracheal caskets as they are found in our American Anseres, continuing the labors of Garrod and Yarrell in that direction.

Anseres always have the extremities powerfully developed, and in consequence we find strong skeletal supports for their pectoral and pelvic limbs. The bones that enter into them, however, rarely offer anything peculiar or make any marked departures from the average type of the skeleton of the parts in Aves.

In Figs. 27 and 34 of Coues's Key I offer drawings of the pectoral and pelvic limbs of *Glaucionetta islandica*, and they give a very good idea of these bones as they occur among the Ducks generally. It must be noted, however, that in Fig. 27 (of the "Key") another small joint must be added at D, in order to perfect the limb. This part of the skeleton in *Glaucionetta* is completely non-pneumatic; not the case with many other Ducks.

It must likewise be observed that in Fig. 34 the patella is not shown, whereas I believe this fowl possesses one in common with other Ducks.

Professor Coues lettered these two drawings of mine himself, and by an oversight has made in Fig. 34 *am.* point to one of the trochleæ of tarso-metatarsus instead of the accessory metatarsal.

Olor, the Teals, and the Spoon-bill all have a perfectly pneumatic humerus, the foramina being found at their usual site.

In the last-named species this bone is considerably longer than the non-pneumatic ulna and radius. Its radial crest is rather low and short, while the ulnar one curls conspicuously over the pneumatic fossa. Between this latter and the humeral head a deep notch, or rather groove, is found.

The shaft is of a glistening whiteness, and composed of a wonderfully compact tissue, and shows scarcely any curve along its continuity. The distal extremity presents the usual characters, the oblique and ulnar tubercle on the radial side and a broad passage for the tendons on the other.

Along the shaft of the ulna we notice a faintly pronounced row of papillæ for the secondary quill-butts, a longitudinal muscular line marking the opposite side. This bone is considerably bowed along its proximal third, while, on the other hand, the radius is nearly straight. The two carpal elements which remain free throughout life in Aves generally are here present, and of a comparatively large size. *Ulnare* in most Ducks, and less so in the Swan, shows a strongly-defined groove down its anconal aspect for the lodgment of the tendon which there passes.

Carpo-metacarpus presents the usual form, and its main shaft is more than two-thirds as long as the radius. There are two phalanges in pollex digit, as there are three in index, the blade of the proximal joint of this latter finger being narrow and solid; the little joint behind it extending rather more than half way down its posterior border.

Among the Swans the general plan of the limb is the same, but the humerus, an exquisitely beautiful bone in these birds, is but very slightly longer than the ulna.

The skeleton of the pinion is quite as we find it in the Ducks.

I have yet to find a true American anserine bird that possesses a pneumatic bone in its pelvic limb. All the species before me entirely lack this character.

In *Spatula* the trochanterian ridge of the femur has a thick, curling crest on the antero-superior aspect of the bone, but at the summit it is leveled down to the same plane with the articular surface. The head is rather large and sessile and the excavation for the round ligament shallow.

We find the distal extremity unusually large; indeed, all the bony structures that enter into a Duck's knee-joint are large and massive. This is particularly the case with the condylar extremity of the femur in *Glaucionetta*, where these prominences are powerfully produced behind, and a wide and deep cleft splits the outer one for the fibular head. In this form, too, a deep pit is found in the popliteal fossa.

Returning to the femur of *Spatula*, we note that its shaft is nearly straight, being marked by the usual muscular lines, while the pit just spoken of is absent. The rotular channel extends slightly up the shaft above the condyles, whereas in *Glaucionetta* this is not the case, and in this Duck the femoral head is notably large and extensively excavated on top; the lower third of its shaft is somewhat bowed to the front and a little twisted, recalling to our mind the power of that peculiar arch as exhibited in such a marked degree in *Urinator*.

The Spoon-bill, and I suppose other Ducks will show the same, has an extraordinarily formed patella, being flat on top, wedge-shaped in front, broad and concave behind, deeply excavated and arched below, while across its anterior face it is profoundly slit in the oblique direction for the tendon of the ambiens muscle.

In the tibio-tarsus we find a large, flake-like, and jutting procnemial crest, which curls toward the fibular side and ends abruptly high up on the shaft. The ectocnemial crest is also turned outward, but is low and thick. These prominences are but slightly elevated above the articular summit of the bone, while in *Glaucionetta* they are carried up in such a manner as almost to rival the Grebe in this particular, having very much the same form.

The tibio-tarsal shaft in *Spatula* is straight, smooth, and subcylindrical. It affords at its outer side the usual ridge for the accommodation of the fibula. This is very long in the Garrot.

At the distal extremity we find that the entire end is considerably bent toward the inner side, a character it presents in many other *Anatidæ*. The intercondylar notch is for the most part very wide and shallow, being deepest anteriorly. Above it, in front, the direction of the deeply excavated groove for the extensor tendons is influenced by the obliquity of the bone spoken of above. The bony bridge that spans it is thrown directly across.

Nothing of particular interest marks the fibula, it having the form we usually find in the class. In this specimen of the Spoon-bill its feeble lower end anchyloses with the tibio-tarsal shaft at about half way down its length. It is very much longer in *Olor*, where its method of ending is the same.

Equaling about half the length of the leg bone it articulates with, the tarso-metatarsus also proves to be a strong, stout segment in the limb of this Duck. Its hypotarsus is flat and inconspicuous, being marked by three vertical grooves for tendons. The four ridges thus formed graduate in size, the innermost one being the longest and most prominent. The sides of the shaft of this bone are, for the major part, flat, a slight excavation being seen at the upper end of the anterior one.

The trochleæ at the distal extremity are very prominent and well individualized by the deep clefts that severally divide them. They all have median grooves passing around them from before backward. The mid-trochlea is much the lowest of the three, as well as the largest, while the inner one is placed the highest on the shaft, being at the same time turned slightly to the rear. The usual arterial foramen occupies its site, as in other birds.

Agreeing with the group generally, *Spatula* possesses but a feebly developed accessory metatarsal, with a correspondingly weak hallux composed of a basal phalanx and claw, the whole being suspended rather high on the tarso-metatarsal shaft by ligament. This discrepancy in size of the hind toe is likewise seen in the Swans, where it is even still more evident. Second, third, and fourth digits, however, having three, four, and five joints, respectively, are quite the reverse from this, being composed of bones fully in keeping, so far as their size and strength go, with the substantial segments of the limb to which they belong.

Of these joints the basal ones take the lead in point of length, and it is only in the outer podal digit of the Duck where we find that its penultimate phalanx exceeds the joint that precedes it in this particular

NOTES ON A SKULL OF BRANTA CANADENSIS HUTCHINSII.

The characters of the skull as they are seen among the smaller of our American Geese are well exemplified in the subject of these brief comparative notes.

This specimen of *Branta* I collected several years ago on the Platte River, in Wyoming, and prepared it as a skeleton at the time.

I present four figures, giving the four principal views of this Goose's skull of the size of nature. Viewing it from the side, we find a superior osseous mandible of the form I mentioned in the synopsis of characters, but much shorter than in Ducks and Geese generally. We note here also that a partial septum narium is present, which is absent in *Mergus* and not a constant character among the others.

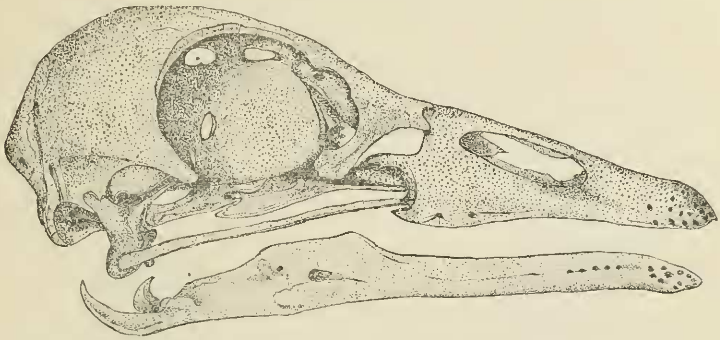

FIG. 27. Skull of *Branta canadensis hutchinsii;* right lateral view; life size. From a specimen in the author's collection.

The lacrymal has the broad descending process, but not so enormously expanded as we find it in the Swans and in *Glaucionetta*. It will also be noted how this tends to approach the sphenotic process of the opposite side of the orbit, which it nearly succeeds in meeting in the Golden Eye.

Again, the condition of the interorbital septum as it is generally formed among the Ducks and Geese is well exemplified in this Goose. Fenestræ occur in the region of the exit of the first pair of nerves, but the center of the plate is impervious. Attention is invited, too, to the form of the palatine, quadrate, and pterygoid on this lateral view.

The crotaphyte fossa is small and inconspicuous, and confined entirely to the side of the head. As in all *Anatidæ*, the entrance to the auricular chamber is thoroughly walled about with bone, without presenting any flaring wing-like extensions as we sometimes see in birds.

The unusual size of the brain-case in Hutchin's Goose is, perhaps, better appreciated upon a direct posterior view than it is here on our lateral one. Comparatively speaking, it is far above, I think, the average for a bird of its size.

Still regarding this skull from the aspect presented, and to make some of its characters still more evident by contrast, we will place it beside the skull of *Mergus*, already described above. We note the difference in the form of the bill; the presence of the cranio-facial line in the Goose, while it is absent in the Merganser. Both have the narrow depressions along the margins of the orbits for the nasal glands, but posterior to this the Goose has the dome-like vault of the cranium so characteristic of the more highly organized types of the *Anatidæ*, while we see that this region in the Merganser is much flattened.

Regarding the skull from the under side, we are particularly to note the difference in form of the maxillo-palatines, the palatine bodies, and the pterygoids.

The vomer varies but little among the genera of this order. When describing it for *Mergus serrator* it was said how its superior border was finished off by a thickened rib. I find in an immature specimen of *Glaucionetta islandica* that the most of this is contributed by the ascending processes of the palatine on either side, each sending a delicate anterior process over the upper margin of the vomerine plate. In mature skulls of Ducks and Geese the sutural traces of this condition of affairs are obliterated, and from an examination of a skull of an adult Duck we would be very much inclined to think that this thickened upper rim of the vomer was a part of its own ossification.

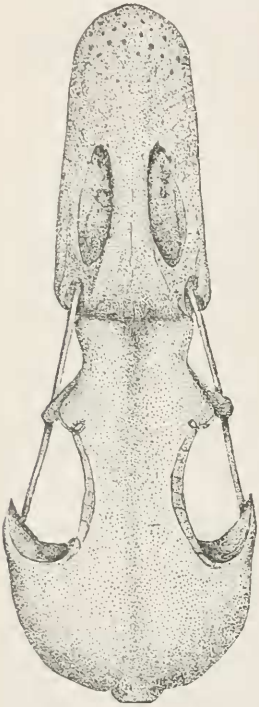

Fig. 28. Skull of *Branta canadensis hutchinsii*; rom above. Same specimen as Fig. 27; life size.

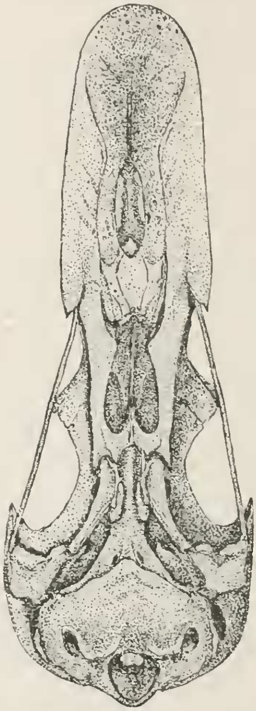

Fig. 29. Skull of *Branta canadensis hutchinsii*; basal view with mandible removed; life size. Same specimen as Figs. 27 and 28.

Seen from behind (Fig. 30), we find the plane of the periphery of the foramen magnum nearly at right angles with the basis-cranii, as in *Mergus*; but the chief feature that strikes us here is, as already alluded to, the great superiority of the Goose over the Merganser in its more capacious brain-case, which, of course, is indicative of the possession on the part of the former of a comparatively and correspondingly much larger encephalic mass.

In comparing the characters of the skull in *Mergus serrator* with the corresponding ones as we find them in the majority of the Ducks, Swans, and Geese, I find them to differ in the following general particulars:

The skull in *Mergus serrator:* Osseous mandibles long and narrow; lacrymo-frontal suture persistent; descending process of lacrymal spine-like; interorbital septum largely deficient at its center; mastoidal head of quadrate single; trochleæ of mandibular foot of quadrate with their long axes placed nearly parallel with the long axis of the skull; maxillo-palatines for their anterior halves meet in the median line, posteriorly they are produced as distinct cylindriform processes with free extremities; pterygoids long, of equal width, and concave outward.

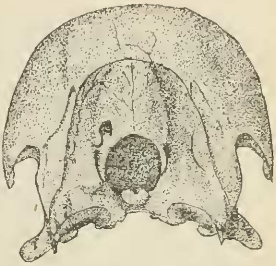

FIG. 30. Posterior view of skull of *Branta canadensis hutchinsii;* mandible removed; life size. Same specimen as Fig. 27 *et seq.*

As a rule, in the skull of Ducks, Swans, and Geese the osseous mandibles vary in length, but are always broad and of a lamellar structure; lacrymo-frontal suture obliterated; descending process of lacrymal much expanded, with flat surface directed outward; interorbital septum very rarely shows a small central vacuity (*Glaucionetta*); mastoidal head of quadrate usually double; trochleæ of mandibular foot of quadrate with their long axes placed nearly at right angles with the long axis of the skull; maxillo-palatines fuse in the median line for their entire lengths, no posterior processes; pterygoids short, straight, and much larger anteriorly than they are at their proximal extremities.